Incorporating "The Illuminating Engineer."

Light and Lighting

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Principal Contents:

We Still Need Light

THERE still seems to be a certain impression that the Black-Out Outside means No Light Inside—or at least very much less than in normal times.

That this does not apply in any degree to factories is shown by the relatively high values of illumination now demanded by the Authorities and by the intense efforts being made by the light-industry to bring conditions for those engaged upon work of national importance up to the prescribed standard.

Moreover, whilst main insistence is placed on the lighting of factories, as an essential to efficient production, the same consideration applies broadly to all offices and other places where work is done. There is no lack of demand for lighting schemes for new buildings devoted to important productive work.

In regard to luxury demands for shops, restaurants and places of entertainment, there can, naturally, be little in the way of new developments in war time, but even here the existing lighting must be maintained, and the occasional damage suffered made good.

Finally there remains the overseas demand, notably in the British Empire.

Most makers of lighting equipment are exceptionally busy and are likely to remain so. It is only the direction of their efforts that is necessarily modified in war time.

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Lighting Fittings for Providing Low Illumination

Recent discussions at the I.E.S. meeting on the subject of British Standard Fittings for low illumination drew attention to the fact that there are other methods of providing low illumination besides those adopted in the Fittings described in detail in B.S. Specification ARP/16. This is indeed clearly indicated in the specification itself, which presents designs of possible fittings only as *examples* of one way of meeting the fundamental requirements stated in the initial clauses. The best method of attacking the problem depends largely on the spacing of fittings. When these can be mounted fairly close together reasonably even illumination may be secured without its being necessary to secure a relatively high candlepower at angles slightly below the horizontal.

The B.S.I. and I.E.S. Joint Committee have in another Specification (ARP/36—Shelter Signs) given an indication of one very useful principle, viz., the provision of a baffle which secures that the source of light becomes wholly indirect. It is quite possible to provide effective low illumination fittings on similar lines by having a fairly large upper reflector and a baffle beneath the lamp arranged so that the illumination is suitably diminished. A simpler method still, where large-sized reflectors are already in use, is to coat the standard 15-watt lamp so as to reduce its candle power. (It is, of course, necessary to keep an eye on the lamp so as to be sure that the coating remains in good condition.) When this is done, provided the upper reflecting surface is fairly large in area, a very suitable low illumination results, depending for its effect on making the source of illumination of large area and low brightness.

The absence of this low brightness seems to be the chief point of criticism in the original BS/ARP 16 Electric Light Fittings, which were considered by some to be unsatisfactory mainly because there was a narrow zone in which a relatively bright source of light could be seen, creating an effect liable to cause glare at these very low levels of illumination. In the revised Specification for close spacing this objection is overcome by the use of a translucent screen.

Fluorescent Lighting in U.S.A.

Some striking figures relating to the development of fluorescent lighting in the United States were recently given in the "Electrical World." 250 million dollars will, it is estimated, be spent thus during the present year, when an output of 20-25 million tubular lamps is anticipated. It is somewhat remarkable that this development does not seem to be causing any shrinkage in the output of filament lamps which attained the huge figure of 600 million during 1940. There will, doubtless, be a big development in this field in our own country when the war is over. The same applies to another field of fluorescence—the use of ultra-violet energy to excite fluorescent materials used for decorative effect.

The Visibility of Distant Lights

References have recently been made in the daily Press to the visibility, during black-out conditions, of sources of light. Tests abroad are quoted to the effect that a lighted match is visible for more than half a mile, a stable lantern for a mile and a quarter, and a fully-lighted window at 12½ miles. Actually, such figures vary greatly according to atmospheric conditions and the condition of the observer's eye. We seem to have heard it stated that in a very clear atmosphere a candle flame may be seen at a distance equivalent to the height of Mount Everest. In this country a perfectly clear atmosphere is unusual, and the distances must often be greatly limited by ground mist or fog. There is also the effect of natural light, e.g., bright moonlight, to consider, and the fact that a faint "spread of reflected light" can sometimes be seen when no actual source is visible.

Diffusion of Light by Dust

Much has been said in regard to the "tunnel effect" in completely blacked-out factories and the desirability of producing a cheerful general effect by the use of light coloured surroundings. There is another point in connection with factory lighting that deserves consideration—the effect of a dust-laden atmosphere in producing a species of luminous mist, which some operators find annoying, and which in any case is apt to give the impression that the ventilation is inadequate. In the case of some industrial processes the presence of some dust or fumes in the atmosphere can scarcely be avoided, and whenever this condition arises a "hazy" appearance of the atmosphere is apt to become evident in strong light. It has been pointed out recently by Mr. E. W. Murray that in the case of rooms which are lighted by overhead windows during the day, but receive downward light from artificial light fittings during the night, the presence of dust particles is apt to become more noticeable when the artificial light is switched on. This is possibly due to the particles of dust being more strongly illuminated by the more concentrated beams of artificial light, as compared with the diffused daylight. If so, this is another argument in favour of the use of lighting fittings of large area and low brightness for factory lighting. It seems evident, however, that the use of light coloured walls and ceiling, to which some artificial light illumination is deliberately furnished, would form one of the most potent means of diminishing the apparent haze, which is naturally much more pronounced when viewed against a dark background. Lastly, it should be remembered that the condition of the eyes of operatives has a bearing on this lighting problem, as on many others. A tendency to become unduly conscious of luminous haze may be caused by defects of the eye-lens, or by the formation of slight films thereon, which tend to scatter the light.

Twilight Photometry

We give elsewhere a summary of the address given by Dr. Walsh to the Illuminating Engineering Society on April 8, in which he reviewed progress in the design of gauges and photometers for measurements of very weak light. The address was admirably delivered and illustrated very clearly the difficulties with which photometric experts have had to grapple since the outbreak of war, firstly, in working at such very low orders of illumination, and, secondly, in dealing with light of all sorts of colours, such as those presented by fluorescent substances, and with all the complexities introduced by the Purkinje effect. It is singular to reflect that it has required the experience of war-time to induce experts to break boldly away from established practice and to introduce a new basis of photometry and a new unit of effective brightness, reliance on a physical basis of measurement being replaced by methods based upon the impression received by the eye. At the conclusion of his paper Dr. Walsh remarked that it was refreshing, after photoelectric photometers had come into such general use during recent years, to find visual photometry coming into its own again. But the old guard may well ask where is this to stop. If we once substitute apparent brightness for calculated brightness in order to avoid the consequences of the Purkinje effect, may we not presently be asked to make similar provision for the depressing effect of glare, to substitute real brightness of the field of work for estimated foot-candles, and to adopt in daily life a " scale of apparent brightness," such as that recently introduced to I.E.S. members by Dr. W. D. Wright?

White Light or Blue?

The other contribution at the last I.E.S. meeting in London, that by Mr. J. S. Dow, dealing with visibility by white and coloured light, put very clearly the case for using ordinary white light for general illumination in war-time, irrespective of possible advantages of coloured light for some special object. The fact that it is necessary to put up with an absorption of as much as 99 per cent. of the original light, in order to obtain *pure* blue light from incandescent sources provided with filters, is surely sufficient reason to avoid the use of blue paints and lacquers, quite apart from other practical difficulties, such as those of supply and permanence. But this is not to say that special applications of pure blue light or other coloured light may not be found, and the analysis of their effects, aided by experiments, gave rise to an interesting discussion. The effect of chromatic aberration of the eye on the ease with which objects illuminated by red, white, or blue light could be seen at a distance was the point seized upon by most speakers, probably because these effects are at once so striking and so much affected by the personal equation. The difference in opinion evident in the minds of the audience in regard to the comparative sharpness of objects illuminated by pure red and violet light was, perhaps, greater than might have been anticipated, though somewhat similar experience was reported when this problem was last brought before members of the Society some twelve years ago. There is, no doubt, a good deal still to be learned in regard to the value of pure coloured light in the solution of specific problems and in connection with special industrial problems. The experience of the evening seemed, however, to justify the belief that white light will continue to prove best for all ordinary purposes.

The Physical Society " Colour Group "

The next meeting of the Colour Group will be held at 2.30 p.m. on Wednesday, April 30, 1941, at the Royal Photographic Society, 16, Prince's-gate, London, S.W.7.

Mr. H. W. Ellis, B.Sc., F.I.C., will demonstrate the samples illustrating his paper on "Colour Tolerance," which he was unable to demonstrate at the last meeting on February 12.

A paper on " Colour Terminology " will be read by Mr. H. D. Murray, M.A., F.I.C., and will be followed by a discussion to which representatives of various trades have been invited to contribute.

Tea will be served at 4.30 p.m.

The Illuminating Engineering Society

(Founded in London, 1909; Incorporated, 1930),
32, VICTORIA STREET, LONDON, S.W.1.
Tel.: ABBey 5215.)

ANNUAL GENERAL MEETING

The Annual General Meeting, to be followed by an ordinary sessional meeting, will take place in the Lecture Theatre of the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1, at **3 p.m.**, on **Tuesday, May 13th, 1941,** when the proceedings will be as follows:—

The Annual Report of the Council and Statement of Accounts for the past year will be submitted and the usual Resolutions approving their adoption and the appointment of Auditors for the coming year will be put to the meeting.

It is also hoped to present for approval the final version of the revised By-Laws, endorsed by members at the Extraordinary Meeting on December 5th, 1939, which have since been edited and arranged in a somewhat shorter and simpler form, as the result of legal advice.

Thereafter the usual formal business of sessional meetings will be transacted, and an Address, reviewing Lighting Problems Involved in Post-War Reconstruction, will be delivered by Mr. R. O. Ackerley.

INFORMAL LUNCHEON

An **Informal Luncheon** has been arranged to take place at **St. Ermin's Hotel,** Westminster, at **1 p.m.,** on Tuesday, **May 13th.** Attendance will be confined to members of the Society.

Tickets (price 6s. 6d. each) may be obtained on application to the Hon. Secretary.

As the space available is limited early application for tickets is advised.

Fluorescent Lighting in Chemical Laboratory

An interesting application of fluorescent " daylight " lamps in a Government factory in which chemical processes are carried out is reported by Crompton Parkinson, Ltd. Four 80w. lamps, furnishing 120-150 ft.c. over a working area of 6 ft. × 4 ft. 6 in., met requirements completely. The illumination enabled the delicate colour changes marking the stages in the addition of acids to a liquid solution to be clearly recognised. For this purpose both high illumination and a close resemblance to the spectrum of daylight are desirable.

Gauges and Photometers for Very Weak Light

Summary of a paper read before the Illuminating Engineering Society by Dr. J. W. T. Walsh on Tuesday, April 8, 1941.

In his paper on "The Measurement or Gauging of Low Values of Illumination and Brightness," read before the Illuminating Engineering Society on April 8, Dr. Walsh remarked on the very low orders of illumination or brightness which it is often desired to measure in under war-time conditions.

The Lighting (Restrictions) Order, 1940, mentions the following permissible maximum values of illumination:—

0.001 ft.c. at ground level outside a public vehicle (§25c.).

0.002 ft.c. for railway stations, docks, etc. (§§45s, etc.).

0.1 ft.c. on the seats of a public service vehicle (§25b).

0.02 ft.c. and 0.2 ft.c. are also values which may be permitted.

Certain limiting values of brightnesses are also mentioned, namely:—

0.002 e.f.c. for shop signs (§40).

0.5 c./sq. ft. for refuge lamps (§6d).

Compliance with regulations may be tested by an illumination gauge (analogous to the "not-go" gauge of the mechanical engineer), but for experiment or design a photometer is necessary.

DIFFICULTIES.

The difficulties are twofold, the loss in the precision of measurement inevitable when the brightness is low, and the Purkinje effect accentuated under these conditions, which still prevails photometrically even at brightnesses so low that sense of colour is largely lost. Whereas a contrast of 1 per cent. is detectable under ordinary conditions, this percentage rises to four at 0.01 foot-lambert (one "equivalent foot-candle") and to ten at 0.001 foot-lambert. With an illumination of only 0.001 ft.c. on the test plate 20 per cent. is about the best accuracy that can be expected from a skilled observer

COLOUR DIFFERENCE.

The onset of the Purkinje effect from a brightness of about half a foot-lambert downwards makes it necessary to define more precisely the meaning of values of illumination or brightness measured with an ordinary illuminometer or brightness gauge when these values are very low.

It might be agreed that all values should be expressed as fractions (obtained by some mechanical means such as a sector disc or a neutral filter) of some brightness well above the limit mentioned above. Unfortunately, a normal observer, if called upon to estimate similar illuminations computed according to this system would find them to be far from equal. He would say that the illumination by the blue light was higher than that under the white light, and that both were much higher than when the light was red. The system of measurement would thus fail to give results even roughly in agreement with visual impression.

The alternative is to base the scale of measurement on mechanical sub-division of a high illumination by light of *one* agreed colour and to assess values for all other colours by visual comparison with this. Clearly the results so obtained will agree with the judgment of "the man in the street," and a system of this kind has now been adopted for such practical matters as the measurements of the brightness of fluorescent and phosphorescent paints. The agreed colour in which the scale is set up is that of the light given by a tungsten filament vacuum lamp (colour temperature 2360°K). In most illuminometers the comparison lamp inside the instrument gives light of approximately this colour. On this system one cannot apply the inverse square law to the calculation of illumination in the case of coloured light, and one might speak of "apparent illumination" if the light is coloured, just as brightness so measured is termed "apparent brightness." The Purkinje effect is absent, or, at any rate, unnoticeable, when the angular size of the surface viewed is small. Therefore, when measurements of illumination or of brightness are being made, the size of the field of view should be at least 5 degrees under normal conditions of use.

ILLUMINATION GAUGES.

Several types of instruments have been devised to enable low values of apparent illumination to be gauged. One form depends on the use of a self-luminous radio-active compound to illuminate the comparison surface. This instrument has already been demonstrated to the Society*, and a description of it as commercially available has recently appeared.† It does not seem necessary, therefore, to give a detailed description of it here. The other commercial form of gauge is, in essence, an illumination photometer with provision for fixing the controlling handle at one or more positions corresponding to the values of illumination to be gauged. This instrument, too, has been demonstrated to the Society and described in "Light and Lighting."‡

Both of these instruments have been designed to comply with the Specification BS/ARP.30 of September, 1940, in which the various matters mentioned earlier in this paper have been taken into consideration.§

ILLUMINOMETERS FOR LOW ILLUMINATION.

Instruments intended for measuring very low values of illumination do not generally differ in their essentials from other types of illuminometer to which the illuminating engineer is accustomed; in fact, the need for a specification for such instruments has been met by quite brief additions to the ordinary Specification for Portable Photometers (230—1935). The new range introduced is 0.0005 to 0.3 ft.c., and the corresponding limit of error laid down is 20 per cent., plus 0.0001 ft.c.

There is one important difference between an illumination gauge and an illuminometer (quite apart from the fact that the former is for use at definite values only). With an illuminometer the observer can change the illumination of the comparison surface fairly rapidly, and the usual practice is to go out of balance, first on one side and then on the other, two or three times in succession, finally making a setting which is roughly mid-way between the two just-out-of-balance positions. The result should be a setting which is considerably closer to the true value than the percentage contrast which the eye can detect.

With a gauge, on the other hand, it is only possible to judge when the illumination is greater or less than the value to which the gauge is set, by an amount

* "Light and Lighting," November, 1939, p. 231.
† Ibid., December, 1939, p. 232, and January, 1941, p. 3.
‡ December, 1939, p. 231.
§ "Light and Lighting," February, 1940, p. 22, and November, 1940, p. 186.

equal to the minimum contrast just detectable under the existing brightness conditions. Thus, for example, if the gauge is set to 0.02 ft.c., and the brightness of the field of view is the minimum permissible in BS/ARP.30 (say, 0.0002 foot-lambert), so that the contrast sensitivity of the eye is probably about 25 per cent., the field view will go out of balance at 0.02 ± 0.005 ft.c. if the setting of the gauge itself is perfectly accurate. In other words, the value checked by the instrument when used as a "not-go" gauge is 0.025 ft.c. and not 0.02 ft.c. Actually, the contrast sensitivity of the observer's eye may be considerably lower.

Brightness Gauges.

Both the types of illumination gauge referred to earlier can, in fact, be used to gauge brightness, but in some cases this is inconvenient on account of the inaccessibility or small angular dimensions of the surface to be gauged, its marked coloration, or some other reason. In consequence, a specification has recently been issued (BS/ARP.52, Dec., 1940) for a portable piece of apparatus which provides a standard of comparison by which to judge the brightness of any sign, refuge lamp, etc.* The values to which the standard can be set are to be 0.02, 0.04, 0.1, and 0.5 foot-lambert. In an appendix to the specification a description is given of a piece of apparatus capable of fulfilling the requirements. It consists, in essence, of a box containing a lamp fed from a portable battery, one side of the box having a white translucent window, the brightness of which is adjusted to the required value by means of a resistance in series with the lamp. Red or blue screens can be placed over the window when the surface to be gauged is coloured. It is emphasised that the values to be gauged are values of *apparent* brightness.

A special problem in brightness measurement which has recently come into prominence is that met with in studying the performance of luminescent materials. In the specification for these materials (BS/ARP.18)† it is laid down that the brightness under stimulation shall be not less than 0.1 or 0.01 foot-lambert (depending on the class of material), and after a stated time in the dark the brightness shall be at least 0.0001 foot-lambert. In all cases it is *apparent brightness* that is specified, and the importance of this will be clear when it is remembered that the light given by a luminescent material may be of almost any colour whatsoever. A form of brightness gauge suitable for this particular class of work has been devised and is described in the specification. It is an "open-view" type of instrument; there is no eyepiece, and both eyes are used when making the observations. No colour filters are used, and the observer has to make his judgment in the only way possible when measuring apparent brightness, viz., without regard to colour. At the lower values, of course, the disturbing effect of colour difference becomes much less as the eye becomes more and more insensitive to colour.

Conclusion.

From what has been described above it will be seen that present-day conditions have presented the photometric laboratory with new problems. Strictly, of course, the problems are not new, but their existence, although realised, has been largely ignored because they have not hitherto entered into ordinary photometric practice. The necessity for measuring apparent brightness, rather than brightness based on a physical scale, is perhaps the most striking of these new developments. To those who began to think that no further progress could be looked for, at any rate in visual photometry, the present situation comes as a challenge and a welcome stimulus.

* "Light and Lighting," Jan., 1941, p. 10.
† "Light and Lighting," Nov., 1940, p. 185.

APPLICATIONS FOR MEMBERSHIP.

Elections Pending.

The names of the following applicants for membership were presented for the first time at the meeting held on April 8, 1941:—

Corporate Members:—

Cooke, K. J. R. .... 104, Dunchurch Road, Rugby.
Dodgson, J. S. .... 17, Wensley Road, Leeds, 7.
Holtby, R. .... 14, Norfolk Square, Hyde Park, London, W.2.
Rogerson, J. N. .... 92, Elm Lane, Bradford.
Tattlet, J. .... 23, King Edward Avenue, Horsforth, Leeds.

Country Member:—

Fielding, C. .... 16, Hall Road, Hebburn-on-Tyne.

Elections Completed.

The following applicants, read at the previous meeting on March 11 for the second time, were formally declared members of the Society at the meeting on April 8:—

Corporate Members:—

Clery, A. Agar .... 36, Grosvenor Gardens, London, S.W.1
Davis, Basil .... 21, Eaton House, Upper Grosvenor Street, London, W.1.
Eades, E. C. .... "Valhalla,' Marlborough Avenue, Bromsgrove, Worcs.
Pellow, C. H. .... 25, Rochlands Drive, Kenton Lane, Stanmore, Middx.
Thompson, D. M. .... City of Manchester Gas Department, Medlock Street, Manchester, 15.

Associate:—

Lacey, T. A. .... 51, Portland Road, Kings Heath, Birmingham, 14.

Country Members:—

Douglas, J. T. .... 41, Granville Drive, Forest Hall, Newcastle-upon-Tyne.
Jones, Llewellyn .... 24, Whalley Grove, Whalley Grange, Manchester, 16.
Lockwood, C. H. .... 68, Topping Street, Blackpool.
Macartney, H. .... "Woodville," 64, Wilmslow Road, Cheadle, Cheshire.
Strachan, D. A. .... Metropolitan Vickers Electrical Co., Ltd., Metro-Vick House, Northumberland Road, Newcastle-upon-Tyne.

Elections Completed.

The list of applicants for membership whose names had been presented at the previous meeting on February 11 (Trans., Vol. VI., No. 2, p. 36) was again presented, and these gentlemen were formally declared members of the Society.

Transferences from Country Membership to Corporate Membership:—

Bolt, J. N. .... 290, Worsley Road, Swinton, Lancs.
Holmes, J. G. .... 21, Fitzroy Avenue, Harborne, Birmingham.

I.E.S. FELLOWSHIP.

Applications for Fellowship on behalf of the following have been accepted by the Council:—

Crisp, H. D. .... The General Electrical Company, Ltd., 12, Battery Road, Singapore.
Ette, F. S. .... 103, Dove House Lane, Solihull, Warwickshire.
Gillespie-Williams, R. .... 61, Zulla Road, Mapperley Park, Nottingham.
Herbert, George .... 25, Duke Avenue, Muswell Hill, London, N.10.
Imrie-Smith, W. .... 17, Bush Court, Cran Lane, Southgate, N.14.

Problems in Illuminating Engineering

In what follows we give a summary of the discussion at the meeting of the I.E.S. Nottingham Sub-Centre on February 21, 1941, when a number of special problems in illuminating engineering were presented for discussion.

At the meeting of the I.E.S. Sub-Centre at Nottingham, at which Professor H. Cotton presided, the evening was devoted to the consideration of a number of knotty problems suggested by various members. Professor Cotton explained the proposed procedure. The problems would be presented in turn. Expert opinion would be expressed by Mr. Howard Long and Mr. C. J. Allderidge, after which there would be a general discussion, final replies being given by the experts when necessary.

Light for Colour Matching.

Problem "A," presented by Mr. J. B. Sanderson, related to the provision of "*Lighting entirely suitable for colour matching, equivalent to a clear north daylight, of approximately* 50 *ft.c. intensity.*"

In this connection Mr. Howard Long referred to the colour triangle, for the representation of the chief components of a source in the spectrum $R + G + B = 1$, as adopted by the International Commission on Illumination. He recalled that a B.S.I. committee had been studying artificial daylight for eight or nine years. A specification for "sensation matching" was issued about four years ago, and another on colour matching was about to be issued.

Turning to methods of securing artificial daylight, Mr. Long referred first to methods of modifying the colour of light from a source, by (1) filtering excess of one ocmponent, or (2) making an addition to supplement a deficiency. In the case of electric incandescent (tungsten) lamps there is an excess of red, and in mercury lamps a deficiency in this colour. Light from tungsten lamps may be corrected by filters, which entails an absorption of 95 per cent. Any less absorption will produce a light departing from colour matching and approaching or even passing to lower than sensation match. Tubes containing carbon dioxide gas will, under suitable conditions, give a light suitable for colour matching.

In the course of the discussion Mr. J. B. Sanderson said that he had not been able to obtain an exact equivalent of north daylight, the nearest approach being the fluorescent tubular lamp. Colours are, however, difficult to match with certainty under artificial light, especially blues and violets and colour combinations in which these hues play a part. Mr. C. S. Caunt passed round a photograph of a carbon dioxide daylight colour matching installation, and some data comparing its spectrum with that of other sources. The question was raised whether the provision of such a high illumination as that demanded would prove troublesome to operatives. It was pointed out, however, that owing to the moderate brightness of the source no impression of glare should be created.

Inspection of Bottles Containing Liquids.

The problem next taken in order ("D," presented by Mr. C. C. Barnes) demanded "*Lighting to enable bottles containing liquids to be inspected, in order to detect undesired particles of matter, the liquids being of various densities and colours.*"

Mr. Long summarised the essential conditions as follows. Both for empty bottles and in the case of those filled with transparent liquids the provision of a luminous background of low brightness is an effective solution. The background should be of ample area so that the operator may have freedom to hold the bottle in any position when inspecting it. The luminous background may be achieved either by (1) reflection from a light-coloured matt surface illuminated by angle reflectors or projectors, or (2) transmission through a sheet of flashed opal glass of light from lamps, placed a sufficient distance behind it in order to avoid the formation of bright spots, and preferably enclosed on a box with whitened interior.

In the course of the discussion Professor H. Cotton and Mr. Hacking both expressed the view that a concentrated beam of light of high intensity, projected through the bottle from behind the operator, would be better, since the direct rays would pick out more easily any foreign particles in the liquid.

In winding up, Mr. Long agreed that there was much to be done before perfection had been attained in connection with this particular problem.

The Lighting of a Small "Cost" Office.

This problem ("E," presented by Mr. W. S. Thwaite) was defined as "*Lighting of a small 'cost' office, where much close work is done with copying-ink pencil, all contributory causes of eyestrain to be avoided.*"

Mr. Howard Long and Mr. C. J. Allderidge pointed out two main features of this problem, namely, that if direct, semi-indirect, or general lighting were adopted, (1) desks facing the wall would demand a multiplicity of points in order to avoid shadows, and (2) owing to the varied and opposing angles at which the workers are oriented reflected glare from the writing with copying-ink pencils could not be avoided. It appeared, therefore, that indirect lighting was the best solution. The I.E.S. "Recommended Values" prescribed for such purposes an average illumination of 10-15 ft.c.

Taking into consideration the area of the office (8 ft. by 9 ft. 6 in. = 76 sq. ft.), and assuming a utilisation factor of 0.27, and that six points would be demanded, the lumens per point worked out to 3,370. With 300-watt lamps an illumination of 14 ft.c. should be obtained. It was shown that spacing conditions could be readily met.

Mr. Thwaite's own solution, based on the consideration of economy in capital and running cost, was very different. He proposed to use 60-watt "pearl" lamps in intensive opaque reflectors located to the left, and in front of each operator and mounted 18 in. above the desk. General illumination was provided by two opal diffusing pendants, each equipped with a 150-watt pearl lamp. The illumination would be 12 ft.c., and there were no objectionable shadows. The total wattage was 960, as compared with 1,800 required for indirect lighting, and the cost of equipment very much less. Mr. Long suggested that there must be a high diversity factor with Mr. Thwaite's scheme, and Mr. Thwaite agreed that indirect lighting might be preferred if it could be afforded.

Lighting a Large Drawing Office.

This problem ("F," by Mr. C. S. Caunt) involved "*The illumination of a large drawing office, equipped with fixed horizontal and movable tilting drawing boards and large filing cabinets.*" Mr. Howard Long suggested three alternative methods of lighting: (1) indirect lighting, (2) 5 ft. fluorescent lamp fittings, and (3) localised general lighting.

Of these methods (1) was not considered satisfactory, owing to the accentuation of difficulties in connection with the black-out, and because roof formations were often not very suitable. In regard to (2), fluorescent lamps and fittings were now in limited supply and restricted to installations of highest priority, and where there was no satisfactory alternative method. Where available, lamps mounted in trough fittings 7 ft. 6 in. above floor, over and

parallel to the edge of each board remote from the draughtsman, are satisfactory for flat boards. For tilting boards one trough fitting over and parallel to the left-hand edge of each board would be required. The installation would be completed by a trough over the chief draughtsman's table and two 11 ft. above the floor, over the centre of the gangway between cabinets.

Dealing with the problem as presented, Mr. Long pointed out that, assuming method (3) was adopted, the lay-out of the boards was not the most economical possible. He suggested a modification which would permit the use of 300-watt industrial diffusing units installed 7 ft. above floor level. The unit would be placed over the centre of the bench, which was also the common position of the top left-hand corner of each board. Similar positions would be adopted for tilting boards, but the single centre unit would have to be replaced by two, brought to about a foot along the left-hand edge towards the draughtsman, so as to ensure satisfactory conditions when the position of the board approached the vertical. An alternative arrangement of localised general lighting for the boards in the actual present positions was also suggested.

In presenting his own solution of the problem, Mr. Caunt mentioned that of various reflectors tried. Those of the parabolic angle type were found most suitable for situations where flat boards were in use. Opal visors were used to limit glare, and the critical mounting height was found to be 7 ft. above the floor level. The fittings were located over the left front corner of each drawing board and were trained diagonally across, so that such shadow as existed was thrown away from the edges of instruments. With 150-watt pearl lamps good conditions were obtained.

In the case of tilting boards, and using one fitting per board, such a directional illumination was not found to be practicable. A glass-steel diffusing fitting, equipped with a 200-watt lamp and mounted 7 ft. above the floor, and mounted directly over the centre of the left-hand edge of the board, when in the horizontal position was found, in general, to give the best results.

Lighting the Points of Needles of Sewing Machines.

This problem ("C," by Mr. J. B. Sanderson) demanded "*efficient and reliable supplementary lighting for needle points of sewing machines in garment factories.*"

Mr. Howard Long and Mr. C. J. Allderidge, in reporting on this problem, expressed the opinion that needle-point lighting, whilst almost universally adopted in the leather industry, is not favoured by the textile industry, because of the obstruction caused by the needle-point light to the more bulky goods handled. Moreover, only recently has a satisfactory needle-point light for attachment to the machine been obtainable. Accordingly, the best forms of general planned lighting and the positions of lighting units have been closely studied and satisfactory solutions have been found, both for the usual standard benches and for the more recent conveyor-block benches.

Mr. J. B. Sanderson pointed out that general lighting in a garment factory gave from 15 to 20 ft.c. on the working plane. This, however, leaves a heavy shadow directly on the needle point. To overcome this defect 12-volt transformers were installed at each sewing-machine bench, the leads terminating at a 2-amp. 2-pin plug. Armoured flex was taken from the plug to a fitting fixed on the arm of the machine above the needle point, on which the light was directed. This fitting was made from a short piece of 1-in. conduit, into which an end-plate was soldered to carry a small bayonet-cap lampholder. A 12-volt 6-watt lamp in this holder gave sufficient illumination on the needle point.

Professor H. Cotton suggested the use of a fitting built into the arm of the machine, in the form of a tube, as small as practicable, with a detachable connection on the top, carrying the lampholder, lamp, and flex. The other end of the fitting would focus light on the needle point. With such an arrangement there should be nothing to foul the material on which the machinist was engaged.

Electrical Supply in War-time

There was an excellent attendance at the annual luncheon of the Electrical Development Association, which took place at the Savoy Hotel on March 21. There must have been nearly five hundred present, and the gathering included many leading lights in the electrical industry. The Rt. Hon. J. T. C. Moore-Brabazon, Minister of Transport, in proposing the toast of the Association, gave a sparkling address, in which he recalled amusing experiences in the study of electrical problems. He paid a tribute to the forethought that had led to the provision of spares against emergencies throughout the country and to the manner in which the staffs of supply authorities had carried on in spite of aerial bombardment. This point was also taken up, in his reply to the toast, by Lord Lytton, President of the Association, who gave some remarkable instances of the speed with which repairs had been executed in emergencies, and the courage shown by workers at substations and elsewhere. In the present circumstances not much in the way of actual development work is possible, but contact with consumers should be retained and preparation for post-war developments should not be entirely overlooked.

Similar considerations apply to the gas industry, which in some areas has experienced severe trials, and where much heroic work in maintaining supplies has likewise been done. Here, too, there should be prospects of good development after the war when there may be possibilities of co-ordinating the two industries in some national scheme.

Shadows in Industry

This imaginary dialogue, prepared by Dr. K. Norden, who is a recognised expert on shadows and their measurements, deals with the clause in the Factories (Standards of Lighting) Regulations relating to the formation of shadows liable to cause danger or eyestrain. Dr. Norden shows that a shadow may be either beneficial or troublesome according to its position and depth, and that unsatisfactory conditions may often be remedied by improving the diffusing qualities of the source of light, without its being necessary to alter the position of the "shadow caster."

The Illuminating Engineer (Mr. A) and the Factory Manager (Mr. B) were making a common supervision of the lighting conditions in the workshop when the Manager stopped at short distance from a bench where a man was doing some fine mechanical testing. The place appeared to be adequately lit. Then the following conversation took place.

B:—By the way, this man complained some weeks ago of a deep shadow falling across his place. It was caused by the lever of the punching machine over there. By turning the machine by 90 deg. we have since prevented the formation of this troublesome or, as we say, "discomforting," shadow in compliance with Recommendation (7) of the "Lighting in Factories" Report. I am glad there was at last *one* among those Recommendations which a Plain Man like myself was able to carry into effect without having to resort to you expert people.

A:—So you think that there is nothing left for the expert except to give his benediction! Let me, however, analyse the Plain Man's action a little more explicitly.

Shadow is produced by the combination of a light source and a shadow-caster; therefore, its formation could be effectively prevented by removing the caster into a position where it did no more intercept the light emitted from that source.

This method of yours, however, is no panacea. Its limitation is that under service conditions casters are often inherent to the performance of some industrial service and their positions cannot be altered at will. But let us examine your problem a little more closely. Is your man entirely satisfied now?

B:—I suppose so, at least he has made no further complaint.

A and B then approached the site of the shadow, and the Illuminating Engineer closely examined the operation in progress. He observed that when the workman assumed certain positions a broad dim shadow spot, cast by his own head, could still be detected. The Illuminating Engineer, pointing to the shadow, asked the man if it did not disturb him. "It certainly does, sir, but I suppose this can't be helped unless I lose my head," was the reply. The Engineer resumed his conversation.

A:—You see, my friend, it is here where you get stuck, and you have got to surrender to the expert whose control of the qualities of the light sources enables him to influence the nature of the shadow. You understand that "preventing the formation of shadows which cause discomfort" is not only achieved by completely suppressing such shadows but also by reducing their intensity to a level at which no more discomfort is caused.

B:—But the Recommendation fails to define any such level. I always believed you Illuminating Engineers were inexorably pledged to precise numerical definitions expressed in terms of candle-power, angle of elevation, or other measurable quantities. Where such values are missing (as in this case), I do not see why the Plain Man should not be able to tackle the problem just as well as the adept.

A:—On the contrary, "Shadow Engineering" is really one of the most recent branches of our art, rests on solid foundations, and is based on factors quite as well defined as those which you have just quoted. It is only because of its relative novelty that certain fundamental data established by research have not yet become standardised and are, therefore, not included in official Recommendations.

B:—Well, then, go to it. Let us have a taste of whatever medicine you can distil from those ingredients.

A:—I accept your challenge. In terms of medicine, my method is to administer to the shadows an adequate dose of its antidote, which is diffusion.

B:—Is diffusion, by any means, a quantity which can be strictly defined and dosed at will?

A:—It certainly is, but before I can explain this let me give you an exact definition of shadow even at the risk of repeating common knowledge. We define shadow in terms of the ratio of the residue illumination—that is that portion of the illumination which is left in the shadowed area after shadowing has taken place—to the initial or total illumination which prevailed prior to shadowing. The characteristic value thus defined we call the "Shadow Factor." Diffusion, by analogy, involves a "Diffusion Factor," which is the ratio of the shadowless or diffused portion to the total illumination. At the work-place before you, as in the majority of cases, illumination is due to a mixture of direct or shadowy and diffuse or shadowless light; by increasing the proportion of diffuse lighting we can reduce that of the shadowy components and thereby diminish the intensity of the shadow cast by the worker's head.

B:—And how, exactly, do you propose to do this?

A:—I enlarge the area from which light is emitted towards the working area. This is accomplished either by substituting another type of fitting with larger luminous surface for the present one, or by subdividing the units, i.e., by using more but smaller units. The second method does not produce diffusion proper because each additional unit introduces a new potential source of shadow and thereby increases the risk of again intensifying the shadows by crossing or overlapping, which would thwart our design.

B:—From my own point of view I should prefer your first scheme because a greater number of smaller units, apart from the higher cost, as a rule involves a loss in total efficiency. If, however, your first method works out so well, why not make the most of it and provide for a 100 per cent. diffusion?

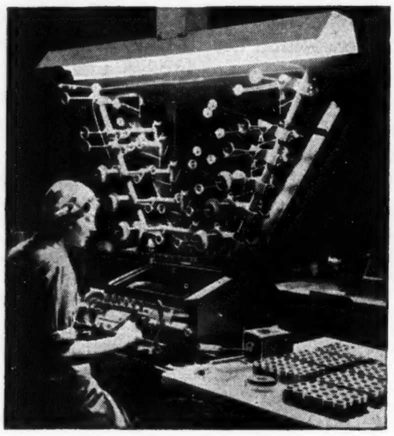
A:—Other considerations apart, this would overshoot the mark. There are not only these objectionable shadows which cause discomfort to persons employed, but also beneficial ones which aid them in getting a plastic view of the form and depth of the objects they are handling and thus contribute to good seeing conditions; we call these "revealing" shadows. While discomforting shadows must be eliminated, or at least minimised, revealing shadows should be promoted as far as possible; their absence would make the contours of the visual objects appear hazy; colours and forms become less vivid and definite. Since, however, with given lighting conditions, the resultant shadow factor must be the same for both groups of shadows, a compromise must be made. We must ensure sufficient insistence and "pronouncedness" of the revealing shadows to cause them to be helpful to vision; but at the same time we must still keep the shadow intensities below the limit of discomfort. This is what Recommendation (7) really means.

B:—That's all very well, but I am still waiting for numerical data.

The Illuminating Engineer produced his Pocket Photometer and put it right down on the work-

WORKERS MUST HAVE GOOD LIGHTING says NEW LAW

(Ministry of Labour Lighting Order, 1941.)



THE BTH LIGHT-CONDITIONING CODE

1. Regard the problem from the workers' point of view rather than from that of the casual observer

★ 2. Eliminate glitter from the work and glitter and dazzle from the local field of view

3. Provide adequate illumination

4. Eliminate dazzle or glitter from the general surroundings

5. Provide reasonable brightness of walls, ceilings or other surroundings

6. Take into account the purely psychological factors by promoting cheerful, comfortable and safe working conditions

7. Employ full engineering and designing skill to keep installation and maintenance costs at lowest level consistent with the best lighting results

BTH LIGHT-CONDITIONING CODE SOLVES ALL PROBLEMS

To promote the welfare of workers and ensure maximum war-time production, factories are now required by law to maintain a high standard of lighting. The BTH Light-Conditioning Code, based on the vast research and practical experience of BTH Lighting Engineers, effectively summarises the requirements of the new Government Order. An intelligent application of the code, in any given case, will provide in the most economical and expeditious manner exactly the kind of lighting needed to maintain maximum output under black-out conditions, without detriment to the health and spirits of the workers.

★ The photograph illustrates the manner in which Point 2 of the BTH Code has been taken care of in one installation which, of course, complies with the new Lighting Order. The use of a low-brightness light source produces a shadowless, well-diffused illumination which minimises glitter or dazzle from polished surfaces.

Let BTH Engineers advise you how to comply with the law and give workers the light they need for maximum production.

Write or telephone to-day.

MAZDA

80w. 60" FLUORESCENT LAMP

with MAZDALUX EQUIPMENT

BTH LIGHT-CONDITIONING *for* PRODUCTION *and* WELFARE

B T-H

M 3875

BTH for all Electrical Plant and Equipment

THE BRITISH THOMSON-HOUSTON CO., LTD., CROWN HOUSE, ALDWYCH, LONDON, W.C.2

bench in front of the workman. The reading taken, in the absence of shadow, was 15 ft.c. He turned back to the Manager.

A:—For this kind of work, as you know, the recommended illumination ranges from 10 to 15 ft.c. The test just shows that we are maintaining the upper value. This leaves us a margin of 5 ft.c. by which the illumination may be reduced without materially impairing the comfort of seeing. If this reduction is due to a shadow we may conclude that a shadow factor equal to $\frac{5}{15} = 0.33$ represents the limit below which seeing in the shadow becomes unsatisfactory. This result, however, would only be a first approximation; in reality the relation is less simple because the obscuration effect of shadows depends not solely upon their photometrical values but also upon certain subjective factors. One of these is "Contrast Induction," which makes shadows appear darker. I cannot go into details of this effect now, but I can tell you from my tables that this familiar phenomenon has the effect of lowering the critical value of the shadow factor in question from 0.33 to 0.27. In other words, the discomfort caused by shadow would already begin to be felt at a residue illumination of 11 ft.c. Another subjective factor affects the colour values of the handled objects, but does not apply to the kind of work which is done here.

While talking, the Engineer had waited for the shadow of the worker's head to fall on the place and then immediately took the reading, which proved to be 9.5 ft.c., i.e., 1.5 ft.c. below the limit of comfortable seeing, thus justifying the man's observation. He demonstrated that there would be no difficulty or inconvenience in remedying this slight deficiency to the satisfaction of the Manager, who apparently was now won over to the views of the Illuminating Engineer. Before the subject was finally dropped one more question was raised.

B:—The Recommendation also mentions shadows "which interfere with the safety." Is there any comment?

A:—This part of the Recommendation, I imagine, refers more particularly to the outdoor lighting of courtyards, passage-ways, etc., or to the lighting of relatively large inside areas. In all such cases dark shadows cast by adjacent objects may occasionally prove misleading. Thus the shadow of a pole or lamp-post falling across the road might be mistaken for a transverse ditch or mound, especially if the edges of the shadow were sharply defined or if the shadow were detached so that at first sight it was not associated with any casting object. Such misinterpretations are more likely to occur at low illuminations and with dense shadows. In all these cases the remedy consists in reducing the shadow factor or increasing the diffusion factor substantially, by measures similar to those explained previously.

Signs of Progress

The review of progress in Illuminating Engineering, which has long been an annual feature in the American I.E.S. Transactions, has undergone some modification of late. Under the title, "Signs of Progress,"* it has assumed a pictorial form, which is certainly much easier to follow than the very detailed and exhaustive summary, with its many references, formerly prepared.

The report is divided into five sections devoted to Light Sources, Lighting Equipment, Measurements, Educational Activities, and Lighting Applications. The subject is introduced by means of a large chart of the spectrum on which the illuminating engineer's domain is plotted out. There is also a tabular summary of recently introduced sources of light for furnishing visible, ultra-violet and infra-red radiation. Amongst the devices mentioned are the so-called "sealed beam" type of headlight, various lamps based on fluorescence, new compact carbon arc projection lamps consuming approximately one kilowatt, and various forms of "drying lamps," which seem to form almost a new industry. A number of unusual fittings for filament lamps, and designs for 100-watt. fluorescent lamps are also illustrated.

There are numerous pictures illustrating unusual applications of light or striking installations. A building is shown floodlighted by means of 30-watt. fluorescent tubular lamps mounted in four silhouette troughs running from top of bottom of the façade. "Protective floodlighting" in yards adjacent to important factories, etc., is being exploited. Supplementary "driving and passing" lamps have been developed to bring the headlighting arrangements of older cars up to standard. To-day it is estimated that upwards of 35,000 foot-candle meters of various designs are in service. Reference is made to a new "street lighting evaluator," which is a mechanical recording photometer for determining the visibility available at various points along a street.

Removal "reflector inserts," very easily detached and reassembled, are facilitating the maintenance of good lighting in factories. Wide use is being made of reflector drying lamps applied to the retouching and finishing of auto bodies—a major industry in America. In the Allegheny Tunnel 250-w. mercury lamps, mounted in two rows and spaced 37 ft. apart, are being used with good effect.

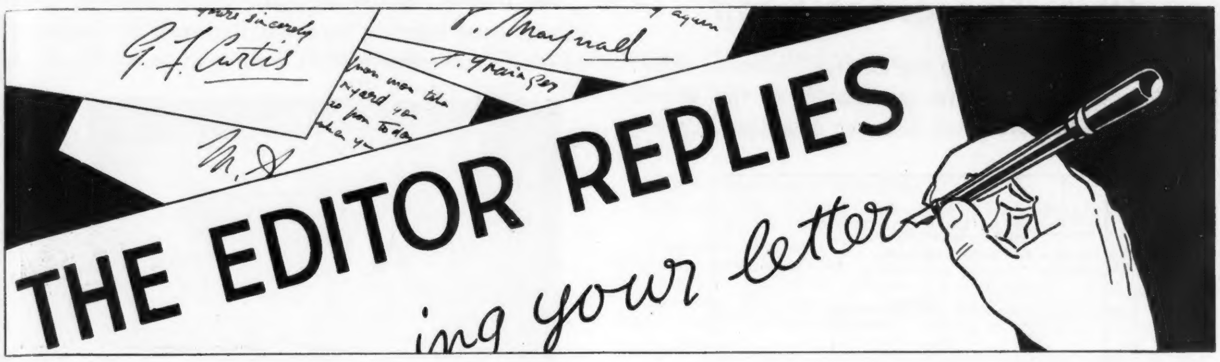
Finally, there is mention of a number of lighting appliances developed as an aid to aeronautics, such as approach lights, "plane to plane" signal beams, and lights for seadromes to mark out safe landing areas on water.

* "Illuminating Engineering," February, 1941, p. 169.

Lighting the Goldsmiths' Residential Club

The Goldsmiths' Residential Club is a new building situated in North-West London, partly equipped from funds provided by The Worshipful Company of Goldsmiths, and serving as a hostel for young working girls coming to London to seek employment.

The interior is of a comfortable but simple character, and the lighting is designed accordingly. In the dining hall, the lounge, the entrance hall, and in the "quiet" room enclosed spherical fittings in bronze are used, and in the many private cubicles "Coolicon" shades are utilised in conjunction with the orthodox pendant-type lamps. Staircases, corridors, bathrooms, and laundry are fitted with ceiling-type lights enclosed in opal glassware. Standard G.E.C. fittings designed mainly for general utility but of neat appearance have been adopted by the architects (Messrs. James and Bywaters and Rowland Pierce). The conditions are well illustrated in the accompanying picture of the lounge of the club. In all about 260 points are installed. The electrical contractors were Messrs. Watmins and Stone (London, W.C.2).



My remarks some little time ago ("Lighting for Obscurity," Jan., 1941, p. 3; Feb., 1941, p. 21) on the changing nature of air operations and the possibility of some **alleviation of the black-out** have brought me further comments, some referring to recent utterances in the daily Press. The position was thus stated in the "Daily Express" on April 2: "Once moonlight seemed to help only the bomber. . . . We were afraid of light. But light has proved our friend. Is the black-out our best protection? Could we not experiment with more light on the ground? Camouflage by lighting must be a first-rate proposition." The trend of events does seem to show that, overhead at least, the presence of light is likely to prove more of a deterrent than an aid to hostile aircraft. If so, some little lessening of the black-out below might be sanctioned by the authorities. Illuminating engineers should be prepared with suggestions.

In connection with **night camouflage** the idea of an imitation England somewhere out in the North Sea is apparently not quite so fantastic as might be imagined. For a "neutral business man" travelling abroad has recently recorded experiments with hundreds of tons of cinders thrown about on the snow in order to simulate relief maps of cities. "It was also stated that a model of Bremen was built on a frozen lake."

Such a model would surely require the use of a record collection of cinders. Seriously, one would imagine that it is quite impracticable to build an imitation city—unless it were hoped that observers from the air would be deceived in regard to the scale as well as the locality—but in other directions the possibilities of night camouflage are, no doubt, well worth exploration.

In connection with "**supplementary local lighting**" discussed in February (p. 32), Dr. Walsh reminds me that in the Fourth Report of the Departmental Committee on Lighting in Factories (p. 27) it is stated: "A local light may be defined as a light so placed as to illuminate only the area or part of the area of work of a single operative or small group of operatives working near to each other."

This seems quite a satisfactory definition of a **local light,** and makes it evident that the committee was concerned mainly with the close proximity of the light to the worker. But it is not necessarily a definition of **local lighting,** which might presumably be secured by a comparatively distant source—though it might, perhaps, be urged that it is local illumination with which we are then concerned.

The definition of **spot lighting** in the B.S.I. Standard Glossary of Terms used in Illumination and Photometry accurately describes this condition, though it speaks of the "localised illumination" of a surface to a brightness considerably greater than that of its surroundings, and refers to a "beam of light," which is not quite what one would have in mind in a factory.

Dr. Walsh also makes a useful suggestion in regard to **literature on searchlights.** There is, he agrees, no comprehensive work of recent date on this subject. But there is a brief treatment of the subject, with a useful bibliography, in "Theory and Design of Illuminating Engineering Equipment," by J. M. Waldram, G. H. Wilson, and L. B. W. Jolley, and likewise quite a good section in the "Handbuch der Lichttechnik."

The question of the best method of giving warning of imminent danger during air raids is still being discussed. I have pleaded for a **visible signal,** as well as an audible one. Apparently this need is to be met in Westminster by an installation of forty cones, to be hoisted on flag poles during daylight raids. Presumably no similar warning is regarded as necessary by night, when there are few people in the streets; but, if need be, some form of luminous signal visible from below, but screened from observation from above, could no doubt be attached to the cones.

My attention has been drawn to the notes recently issued by the Building Research Station on **Anti-Scatter Treatment of Window Glass.** We have learned a good deal about the value of such protection since the question was last discussed in these columns (Oct., 1940, p. 168), but the report seems to confirm in the main the impression then formed that the attachment to glass of strong textile netting is on the whole the best protection, notwithstanding the loss of light involved. Some degree of protection may also be obtained from transparent films, but it is important that they should retain their flexibility on drying and should be reasonably permanent.

I have received a letter from Captain Robert H. Hoare, in regard to the **design of reflectors** intended to illuminate more or less defined areas. Here maintenance of the light source in the correct focus of the reflector may be of some consequence. It is remarked that when lamps are disturbed, or new lamps substituted, the original conditions are rarely reproduced exactly. Captain Hoare suggests that some screw or other adjustment is desirable—more especially when we are concerned with tubular lamps with no rigid end securage. It is also pointed out that in order to make full use of light emerging sideways from such lamps adjustable side reflectors, at present not in general use, might well be considered. The light distribution could then be adjusted more accurately to cover the area it is desired to illuminate.

What is the best form of **artificial daylight?**—a question often put, and recently discussed at an I.E.S. meeting in Nottingham. This point may be treated in a forthcoming contribution to "Light and Lighting." For the moment one is tempted to say that none of the present methods is ideal. From the scientific standpoint it would seem that a source yielding a continuous spectrum is necessary if great accuracy in the imitation of daylight is desired. In this respect the use of incandescent solids, e.g., filament lamps with colour filters, or in connection with pigmented reflecting surfaces (as in the Sheringham Daylight) seems preferable. The efficiency, however, is necessarily low, and this is a definite drawback in these days when such a high order of illumination is demanded.

The carbon dioxide tube is much more efficient, but the spectrum being yielded by luminescent gas is not strictly continuous. Of the new and highly efficient fluorescent tubes, recently introduced, it is perhaps too early to speak. At present apparently, great accuracy in the imitation of daylight has not been sought, but this method might well yield an ideal colour-matching unit.

I see I have used the word "**intensity,**" and am therefore open to possible reproach. I am coming to feel, however, that we *do* need an approved word to indicate "strength" as contrasted with "quality" of light, irrespective of whether one is speaking of candle-power, illumination, brightness, or flux. In the Reports of the Departmental Committee on Lighting in Factories and Workshops the difficulty is avoided by the use of the terms "adequacy" and "suitability," but these terms have a certain official ring, and do not seem to afford quite a happy solution. Can anyone suggest a satisfactory term?

Characteristics of the 80-watt 60-in. Fluorescent Lamp

We have received from the British Thomson-Houston Company, Ltd., some particulars of the above lamp, which has attracted so much attention in view

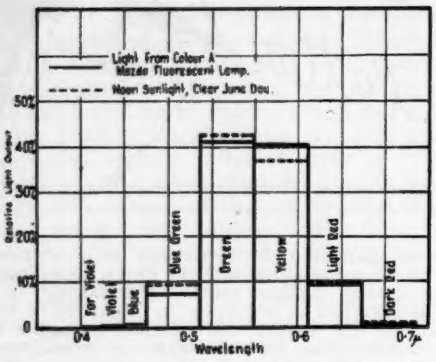


Fig. 1. Showing the resemblance of the spectrum of the Mazda fluorescent lamp to that of noon sunlight.

of its high efficiency and resemblance to daylight. The quality of light, as is well known, is secured by the action of fluorescent materials, applied to the inner surface of the glass tube, which is filled with argon at a pressure of about 1-200th of an atmosphere (with a small amount of mercury added). This is essentially a cool light, the temperature not exceeding 40 deg. C. The diagram above shows the close resemblance of the spectrum to that of noon sunlight.

The high efficiency (35 lumens per watt) and the low brightness (about 3 candles per sq. inch) are good features to which great importance is attached, and even the relatively great length of the lamp, 5 ft., is advantageous in that it contributes to the good diffusion and shadow-free effect.

Another characteristic of the light, illustrated below, is that the stroboscopic effect associated with

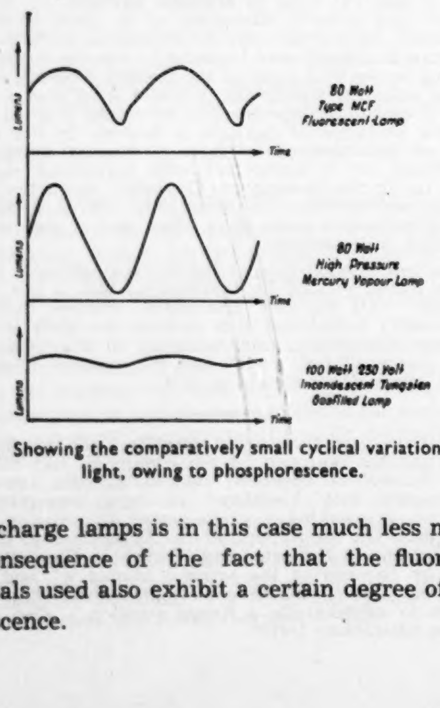
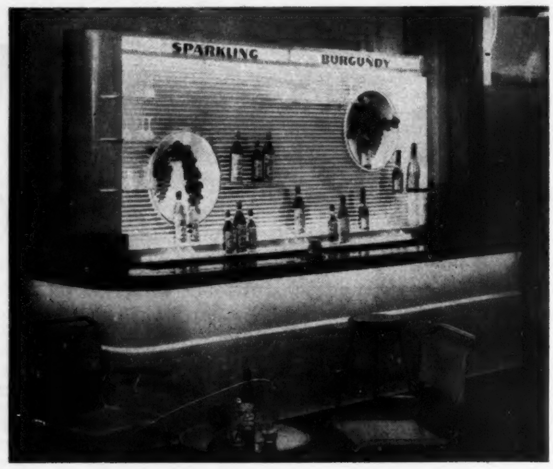


Fig. 2. Showing the comparatively small cyclical variation of the light, owing to phosphorescence.

all discharge lamps is in this case much less marked —a consequence of the fact that the fluorescent materials used also exhibit a certain degree of phosphorescence.

Fluorescence Lighting in Australia

We recently illustrated the installation of fluorescent tube lighting in a woollen mill in Australia, of which some particulars were sent us by Mr. H. A.

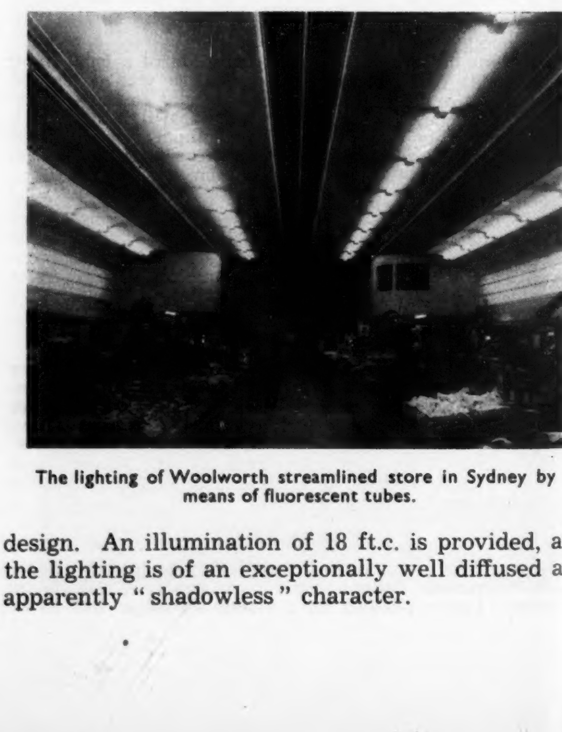


A cocktail bar, one of the show pieces at the Lighting Centre, Sydney, decorated with tubes of white, green, gold, and blue.

Purdie, now associated with The Lighting Centre in Sydney. The two further pictures now presented show the enterprise with which Mr. Purdie and his firm are developing this style of lighting.

The first of the pictures, the "all fluorescent" cocktail bar illustrated above, is one of the show pieces at the Lighting Centre and is interesting as an example of the incorporation of luminous tubes in the general scheme of decoration. The tubes are in white, green, gold, and blue. The background is of specially surfaced hard metallic plaster framed at the further end by a pillar of glass rods. Glassware on the lower shelf is made brilliant by the transmission of light through a series of glass panels stacked edge on. Below is a light channel illuminating the front panels of the bar down to floor level.

The second picture shows the treatment of a large Sydney store with fluorescent tube lighting, which is again very appropriate for the special streamlined



The lighting of Woolworth streamlined store in Sydney by means of fluorescent tubes.

design. An illumination of 18 ft.c. is provided, and the lighting is of an exceptionally well diffused and apparently "shadowless" character.

Literature on Lighting

(Abstracts of Recent Articles on Illumination and Photometry in the Technical Press)

(Continued from page 50, March, 1941)

II.—PHOTOMETRY.

72. An Integrating Photoelectric Meter.

J. B. H. Kuper, F. S. Brackett, M. Eicher. Review of Scientific Instruments, Vol. 12, No. 2, February, 1941.

A photoelectric integrating meter designed to record the amount of erythemal ultra-violet energy in the solar spectrum over a period of months, is described. The instruments employ special photo-tubes with a condenser and cold cathode "trigger" tube, the pulses from the tube being counted by a suitable registering circuit. W. E. H.

73. Sensitive Light Meter with Electronic Amplification.

Anon. The Review of Scientific Instruments. Vol 12, No. 1, January, 1941.

A portable photometer, using electronic amplification and operating from either A.C. or D.C., is described. Four sensitivity ranges are provided. With the most sensitive setting it is claimed that the instrument will read accurately .0005 ft.c. W. E. H.

III.—SOURCES OF LIGHT.

74. Low Pressure Gas Mantles.

British Standard Specification, No. 884, 1941.

The specification prescribes gas mantles in four different types, of stated dimensions, denoted by B.S.$_1$, B.S.$_2$, B.S.$_3$, and B.S.$_4$. A test of depreciation in candle-power is described in an appendix. Mean lighting efficiencies for the respective mantles of 15, 14, 14, and 13 candles (mean horizontal) per 500 B.Th.U. per hour, are demanded. In another appendix breakage and distortion tests during burning are described. J. S. D.

75. The 80-W. Tubular Fluorescent Lamp.

L. J. Davies, H. R. Ruff, W. J. Scott. Electrical Times, Vol. 99, No. 2,576, March 6; No. 2,577, March 13, 1941.

Part I. reviews the development, construction, and theory of operation of the 80-watt fluorescent lamp in some detail. Problems of starting and stabilising are also dealt with.

Part II. deals with the spectral characteristics of the emitted light, the operating temperature, brightness, stroboscopic flicker, and effect of voltage variations of the 80-watt fluorescent lamp. W. E. H.

76. Burning Positions of Discharge Lamps.

Anon. The Electrical Times., Vol. 99, No. 2,577, March 13, 1941.

H.P.M.V. lamps of 80- and 125-watt may be run at any angle without deleterious effect on life or light output. The 250- and 400-watt types are affected adversely, however, if burned in any position except vertically, with cap up. Special lamps have been designed for horizontal and cap down burning, but have a lower efficiency than the standard lamp. W. E. H

77. Radiation from High Pressure Mercury Arc Lamps.

E. B. Noel. Am. Illum. Eng. Soc. Trans. 2, pp. 243-256, February, 1941.

Data is given on the spectral characteristics of two types of water-cooled mercury arc lamps, one commercial and one under development, at operating pressures from 30 to 280 atmospheres. Some commercial applications of the lamps are discussed. J. S. S.

IV.—LIGHTING EQUIPMENT.

77a. Artificial Daylight Fittings for Colour Matching.

British Standard Specification, No. 950, 1941.

As a basis for this specification the I.C.I. standard illuminant "C," representative of average north skylight, is adopted. A definition of colour on the trichromatic system is given, and a limiting diagram based thereon is presented. The method of testing by comparison with a filament of correct colour-temperature is described, and the procedure, involving the use of nine colour filters, explained. In appendices a means of securing the standard illuminant "C" by the use of colour solutions in conjunction with a gas-filled tungsten electric lamp operated by 2,848°K. is described, and an account of an approximate test for determining the colour of a light is presented. Finally, the transmission characteristics of the various filters are specified. J. S. D.

78. Three Dimension Projector.

Anon. The Review of Scientific Instruments, Vol. 12, No. 1., January, 1941.

A projector which, by the use of Polaroid filters in the projector and Polaroid spectacles, gives the appearance of "depth" to projected pictures, is described. A lamp containing two 300-watt filaments is used, making the employment of one continuous strip of film possible. W. E. H.

79. The Heating of Factory and Office Lighting Fittings and Their Connecting Leads.

H. G. Taylor, W. Lethersich, P. D. Morgan. Beama Journal, 48, pp. 27-31. Feb., 1941.

A further instalment is given of the results obtained by the B.E.A.I.R.A. on the healing of lighting fittings and their connecting leads. C. A. M.

V.—APPLICATIONS OF LIGHT.

80. Light and Architecture.

Anon. Am. Illum. Eng. Soc. Trans. 2, pp. 145-150. Feb., 1941.

Some representative architectural lighting schemes are described with photographs. J. S. S.

81. Modelling with Light.

H. L. Logan. Am. Illum. Eng. Soc. Trans. 2, pp. 202-215. Feb., 1941.

A description is given of methods and equipment used in lighting an exhibition of sculpture and discusses their application to commercial display work. J. S. S.

82. Brightness Production by Near Ultra-Violet Radiation.

J. O. Kraehenbuehl and H. J. Chanon. Am. Illum. Eng. Soc. Trans. 2, pp. 151-168. Feb., 1941.

Sources of near ultra-violet radiation and commercially available fluorescent substances are discussed. It is suggested that measurements be made by means of a standard uranium test surface, the brightness of which under excitation by U.V. may be made with a standard brightness meter. A system of units is proposed, based upon a unit of intensity of one milliwatt per steradian. These units correspond to those used in normal photometric practice. J. S. S.

83. Ultra-Violet Excitation of Fluorescent Compounds.

J. W. Marden and N. C. Beese. Am. Illum. Eng. Soc. Trans. 2, pp. 235-242. Feb., 1941.

Spectrographic data are presented to show the wavelengths of ultra-violet radiation exciting various fluorescent material. Such data are of value in selecting the best light source for use with any given compound. J. S. S.

84. The Lighting of Photochemical Reproduction Processes.

R. E. Farnham. Am. Illum. Eng. Soc. Trans. 2, pp. 217-234. Feb., 1941.

The paper describes, with particular reference to electric discharge lamps, the lighting requirements of the processes employed in photo-engraving, lithography, photogravure, and blue printing. J. S. S.

85. Lighting Contrasts.

Anon. Elect. 126, p. 176. March 21, 1941.

A summary is given of a recent paper at the Illuminating Engineering Society dealing with the importance of background brightness as a determining factor in industrial and commercial illumination problems. C. A. M.

86. Factory Lighting Regulations and Lighting Service.

A. D. S. Atkinson. Electrical Times, Vol. 99, No. 2,575. Feb. 27, 1941.

The interpretation of Factory Lighting Regulations, 1941, are considered with particular reference to the interpretation of the clauses dealing with glare, local lighting, and premises which are permanently blacked out. The work of the N.I.E.L.S. in assisting the application of the Regulations is also discussed. W. E. H.

87. Helping to get 100 per cent. Production.

Anon. Electrical Times, Vol. 99, No. 2,575. Feb. 27. 1941.

A lighting installation using 5ft. fluorescent tubes in the machine shops, drawing office, and executive offices of an engineering works is described. Particular stress is laid on the fact that much gauge work is done demanding work of extremely fine limits, and that the fluorescent lighting has been found most satisfactory. W. E. H.

The Planning of Luminescent Installations

With the increasing use of luminescent materials for decorative purposes in illuminating engineering it is becoming desirable to have a technique available which will enable engineers to plan an installation in a similar manner to that adopted for visual installations.

In a paper read before the Illuminating Engineering Society (Trans., I.E.S., Vol. v., No. 5) this problem was discussed, and it was suggested that two methods of approach were possible. The method developed in this paper employed existing visual data and a conversion factor which enabled the luminescent brightness of different materials to be calculated for installations when the light distribution of the fittings was known.

An alternative method requires the polar curves of the fittings producing the ultra-violet radiation to be determined in terms of the brightness of a standard luminescent test surface, and this method has now been elaborated by Kraehenbuehl and Chanon (" Illuminating Engineering," Vol. xxxvi, No. 2).

The authors point out that a fundamental unit for the measurement of ultra-violet energy is watts per square inch, but that in practice this is inconvenient, and suggest the use of a reference (or standard) luminescent test surface whose brightness can be related to the density of the incident energy.

For their own work they have used uranium glass covered on the back surface with vapourised aluminium as a reference standard.

In contradistinction to visual design the final brightness is not the result of a certain illumination falling on a surface of known reflection factor, but results from a conversion of energy. Thus a system is needed which will give a satisfactory transfer of energy from the near ultra-violet to the visual region. By choice of suitable units and nomenclature the design can be carried out in terms of ultra-violet flux, though the final result is obtained in units of visual brightness.

To do this the authors suggest the use of a series of units analogous to those used in visual work and define units of " luminescent-effective " ultra-violet flux ("fluoren "), intensity " fluorpower ", and energy density (" fluoren per square foot "), corresponding to the lumen, candlepower, and foot-candle respectively.

For instance, the fluoren is defined as " the luminescent-effective radiant flux emitted in a unit solid angle from an imaginary uniform point source of luminescent-effective radiation." The total output from a unit uniform point source is then 4π fluorens.

In addition to these units, the term " fluorfactor " is employed, corresponding to the reflection factor of a surface, and is defined as " the factor obtained when the apparent brightness of the luminescent material in foot-lamberts is divided by the fluorens per sq. ft. incident on the luminescent material.

The essential data required in the design of an installation are then the fluorpower distribution curve for the source and the fluorfactors of the luminescent materials used.

The distribution curve is obtained by using the uranium glass standard which has been calibrated in energy units (or fluorpower) against brightness.

The point-by-point method can be applied to determine the resultant fluorens per sq. ft., and thence the brightness of the material, though it is hoped to develop a " fluoren method " comparable to the " lumen method " used in designing visual installations.

W. E. H.

PERSONAL

We learn that Mr. Harold Bright, whose name will be familiar to members of the Illuminating Engineering Sociey, has taken up a temporary war-time post with the Senior Electrical Inspector of Factories. The consulting practice of Richards and Bright will, however, be carried on by Mr. Richards with the aid of the present staff.

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